Technical Series 08-103

Laboratory Depressurization Test for Residential Gas Appliances—Part 2

INTRODUCTION

CMHC partnered with Natural Resources Canada (NRCan) to develop a depressurization spillage test protocol. The research projects described in this *Research Highlight* [1] evaluated the performance of a sample of residential combustion appliances using the new test.

Spillage from combustion appliances is a complex problem. The frequency and severity of combustion spillage is affected by the installation of the equipment and the use of other air-exhausting equipment in the home, which can overpower the appliance venting system.

Existing Canadian codes and standards have attempted to deal with combustion spillage by such strategies as requiring makeup air supplies for installations that may not have sufficient air leakage to support the proper operation of the combustion appliances.

Manufacturers have also developed appliances that are more spillage resistant. Generally, they have either been designed so that their combustion and venting components should not be exposed to the pressure regime inside the house, or they have been equipped with strong power venting systems that should be able to operate even under depressurized conditions.

The first type of product are often referred to as direct-vent or isolated combustion appliances. They are usually vented using sidewall-mounted terminals rather than through a chimney.

Power-vented water heater tanks are one of the more familiar examples of the second type of appliance designed for improved resistance to combustion spillage.

Despite the widespread availability of appliances that have been designed to have greater resistance to depressurization spillage, no standard protocol exists that allows manufacturers to directly test and rate their products for combustion spillage resistance. This means that manufacturers have no accepted way to notify consumers, builders or other stakeholders of the rated spillage resistance of their appliances, or to indicate which of their products perform better under reduced pressure conditions that might cause spillage in other products.

The new depressurization spillage test has been developed as a key instrument towards addressing this gap. The two research projects focused on the performance of contemporary appliances. They did not investigate the depressurization spillage resistance of older designs of combustion appliances that may still be installed in Canadian houses.

RESEARCH PROGRAM

The first research program was conducted between January, 2005 and May, 2005. The second was conducted in the fall of 2007. Testing was done at Bodycote, a Canadian commercial testing laboratory.

In the 2005 project, seven combustion appliances (two water heaters, three furnaces and two fireplaces) were chosen to cover a cross-section of the types of gas-fired equipment that are now being installed in Canadian homes.

The appliances and their venting systems were purchased from regular HVAC distributors, not directly from manufacturers. They were shipped directly to the testing laboratory by the distributors. Each was installed and tested, following the manufacturer's certified installation instructions, using the maximum equivalent length and type of venting materials specified by the manufacturer.

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1 This updates the Technical Series *Research Highlight* 05-111, "Laboratory Depressurization Test for Residential Gas Appliances," published by CMHC in September, 2005.

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In the 2007 project, another 10 combustion appliances were tested, including a condensing storage-tank water heater, two tankless water heaters, a wall-hung boiler, two fireplaces and four furnaces.

The spillage test incorporates a "pass" threshold of two per cent spillage. This figure was chosen to give some flexibility in the choice of test instrumentation and it provides a small margin for errors associated with cumulative uncertainties in the testing procedure and the required measurements.

This is the same tolerance that is used in static leakage tests for combustion-vent sections of sealed-combustion appliances that operate with positive vent pressures. Such appliances already require vent-leakage tests according to existing appliance certification standards (for example, CSA 4.3, CSA 4.9, CSA B140.0). However, it must be understood that static leakage tests are performed at different pressures and they are performed with the appliances and their vent systems at ambient temperature, not operating.

Acceptance of the two per cent "pass" tolerance for the spillage test should not be construed as a judgment that two per cent combustion spillage would be acceptable performance for combustion appliances. Indeed, two per cent spillage from certain types of combustion appliances may not be acceptable for all installations.

THE SPILLAGE TEST

The following briefly describes the depressurization spillage test. In figure 1, the box with a flame represents the combustion appliance installed inside the depressurized test room. The horizontal ducts (with white arrows) attached to the appliance represent the combustion air inlet and the combustion vent.

The appliance is shown drawing its combustion air from outside the test room and exhausting its combustion products outside the test room. Some appliances draw their combustion air from inside the test room. The vertical lines represent the thermal load and output from the appliance that may either be released inside the test room or ejected outside the room (ejection is simpler for products that heat water, such as water heaters and boilers).

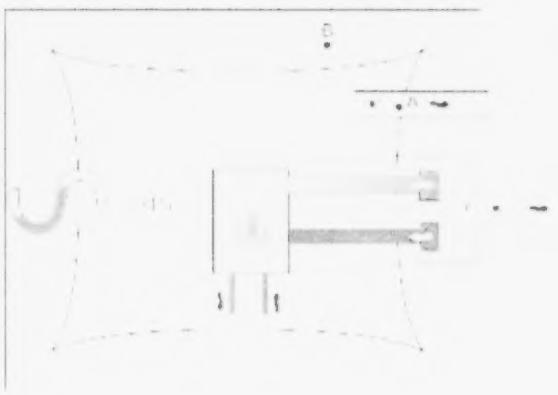

Figure 1 Simplified concept of the depressurization spillage test

The test room is depressurized (by 50 Pa in the illustration) with respect to its surroundings using a variable fan installed in duct "A" that discharges outside the building. A supplemental exhaust system, "C," captures and removes the combustion products to avoid contaminating the area "B" around the test room.

The appliance is operated to obtain five minutes of burner operation. The amount of CO_2 that was released or "spilled" into the test room is determined over five minutes and an additional two minutes (to include any spillage of combustion gases from the venting system after the burner shuts down). The amount of CO_2 (carbon dioxide) that was spilled into the test room is divided by the amount of CO_2 that was produced by the burner during the test to calculate the percentage of combustion spillage.

For each unit, the test was initially performed with the test room depressurized by 50 Pa compared with the pressure outside the room. If the combustion spillage exceeded two per cent, the test was repeated with the room depressurized by 20 Pa. Finally, if the measured spillage exceeded two per cent at 20 Pa, a test was performed with the room depressurized by five Pa.

RESEARCH FINDINGS

The spillage test was relatively easy to perform. Of the 17 gas-fired appliances tested at 50 Pa depressurization, eight had no detectable spillage; six had minor, but measurable spillage; and three had spillage greater than the two per cent threshold. Table 1 summarizes the test results.

Based on these test results, it is evident that many existing products are capable of performing well when depressurized. At the same time, other products that appear similar do not perform as well. The new test can reliably identify those products that perform well.

Because of the two per cent spillage tolerance, this test may have difficulty in conclusively differentiating between a close "pass" and a marginal "fail." If such a spillage result were obtained, further investigations and repeat tests would likely be warranted before reaching a conclusion.

In the first project, the closest result to the spillage threshold was 1.55 per cent for one product. While higher than ideal, that test result was more than 20 per cent below the proposed limit. The result was considered to be a "pass."

Similarly, in the second project, one appliance had 2.6 per cent spillage at 50 Pa depressurization, just above the threshold. This was considered a "failure." The manufacturers of both products, however, should be looking at their designs in light of the test results, and implementing improvements so that their appliances can match the performance of competing devices.

IMPLICATIONS FOR THE INDUSTRY AND OTHER STAKEHOLDERS

The facility and instrumentation requirements for the depressurization spillage test are low enough that manufacturers should have little or no difficulty in setting up the test in their own facilities and using their test facilities as a product development tool. This will enable them to verify the performance and improve the

Table 1 Laboratory test results for "spillage-resistant" gas-fired appliances

Appliance	Year of research	Direct vent (D) or power-vented (P)	% spillage		
			@ 50 Pa	@ 20 Pa	@ 5 Pa
Power-vented water tank A	2005	P	1.1		
Power-vented water tank B	2005	P	1.6		
Power-vented water tank C	2007	P	0.5		
Tankless water heater A	2007	D	0.2		
Tankless water heater B	2007	P	0.1		
Wall-hung boiler A	2007	D	0.2		
Non-condensing furnace A	2005	P	0.2		
Condensing furnace* A	2005	P	0.0		
Condensing furnace B	2005	P	0.1		
Condensing furnace C	2007	P	0.6		
Condensing furnace D	2007	P	-0.5		
Condensing furnace E	2007	P	0.0		
Condensing furnace F	2007	P	2.6	1.4	
Fireplace A	2005	D	13	3.5	0
Fireplace B	2005	D	0.7		
Fireplace C	2007	D	10.3	2.0	0
Fireplace D	2007	D	1.0		

*The condensing furnaces could be set up either as a direct-vent (two pipe) or power-vented (one pipe) appliance. They were tested as power-vented.

spillage resistance of their products.

The spillage test is a new tool that allows manufacturers to include depressurization-spillage-resistance ratings in their literature alongside their other product performance data. It is anticipated that the spillage test will be immediately useful to manufacturers who want to emphasize the performance of their products in depressurized environments, such as in houses with large exhaust appliances.

The test results for 17 gas appliances show that these "spillage-resistant" devices generally operated safely at up to 50 Pa of depressurization, which is what Canadian codes and standards have been implying in recent years. A small number of appliances have excessive spillage. Integration of the spillage test into gas appliance standards would catch those appliances with poor design and detailing, and keep them out of houses with potentially high levels of depressurization.

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CMHC Project Manager: Don Fugler

Consultant: Peter Edwards

Housing Research at CMHC

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or contact:

Canada Mortgage and Housing Corporation
700 Montreal Road
Ottawa, Ontario
K1A 0P7

Phone: 1-800-668-2642
Fax: 1-800-245-9274

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